From Skepticism to Taking Action: Climate Change and Coral Bleaching

Coral Reefs, Climate and Coral Bleaching Workshop

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June 18-20, 2003
O'ahu, Hawaii

Presentation Outline

- Review of 24 Year history of coral bleaching
- Evidence of intensification of bleaching
- Scientific dialogue regarding bleaching
- Management issues related to bleaching
- Management solutions

“Coral bleaching and mortality rank as probably the major threat to the reefs in the Pacific.”

Clive Wilkinson - 2002

Climate Trends

Status

- 10 warmest years on record have occurred since 1983
- 7 of these since 1990
- Fastest global warming rate in 10,000 years

Coral Bleaching

- Intensified over the past two decades
- Seems to be synchronized around El Niño events ……(Peter Glynn, 1984)
- Elevated ocean temperatures
- Related secondary impacts

Coral Bleaching Trends

1979

- Massive die-off of barrel sponges (*Xestospongia muta*) in the Lower Florida Keys

1980

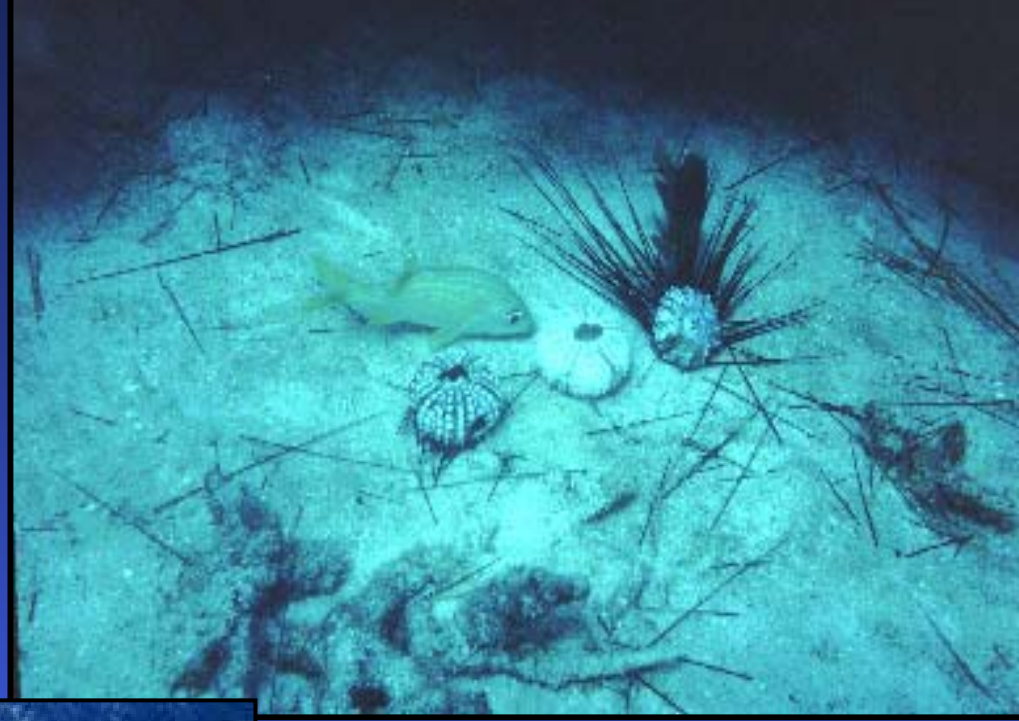
- 6 weeks of doldrum-like weather (slick-calm sea)
- Massive fish kill along reef tract
- Minor bleaching

1983

- 4 weeks of doldrum-like weather
- First large-scale coral bleaching on Lower Florida Keys outer reefs
- Long-spined sea urchin die-off
- Yellow Sponge Die-off

1983 Coral bleaching Lower Florida Keys

"From a distance, spurs looked like snow-draped ridges." …Walt Jaap(1985)

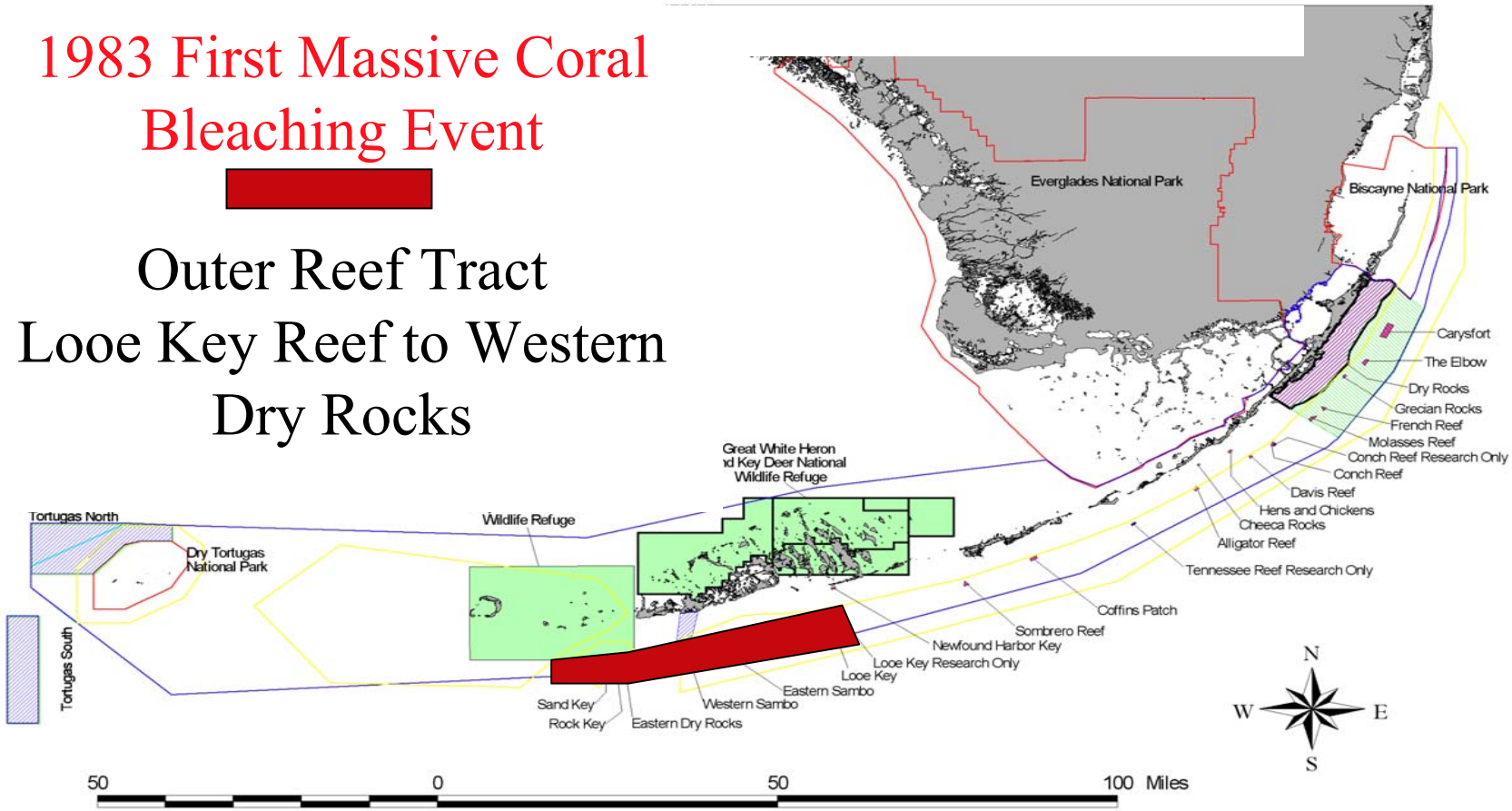


1983 *Diadema* die-off

Florida Keys National Marine Sanctuary

1983 First Massive Coral Bleaching Event

Outer Reef Tract
Looe Key Reef to Western Dry Rocks



“The zooxanthellae expulsion in the Florida Keys during 1983 was most probably the result of elevated temperatures.” ….*Walt Jaap (1985)*

However, we did not learn until later that:

"Eastern Pacific reef corals began bleaching in some areas [off Panama] by January 1983, and continued in 2-3 bouts until December."

…….. Peter Glynn (1983, 1984)

Coral Bleaching Trends (Cont.)

1986

- **Large-scale black-band disease** outbreak in the Lower Florida Keys

1987

- Doldrum weather patterns
- Massive bleaching throughout the Florida Keys
- Restricted to outer reef tract

* **Local, regional, and global**

* **Atlantic & Pacific bleaching event**

1986 Black band disease
Looe Key Reef

1987 Global coral bleaching event

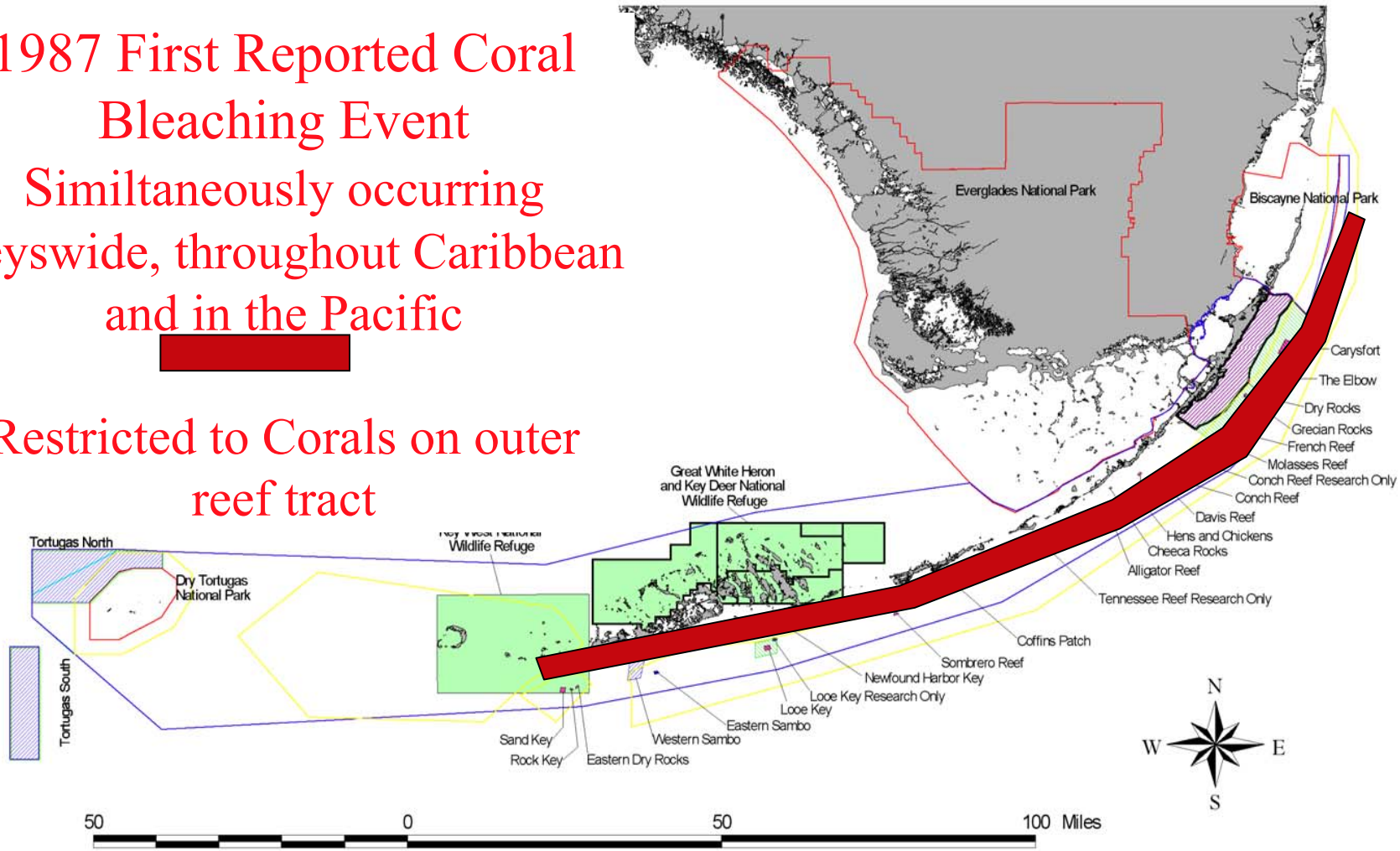
Looe Key Reef

Florida Keys National Marine Sanctuary

1987 First Reported Coral Bleaching Event

Similtaneously occurring Keyswide, throughout Caribbean and in the Pacific

Restricted to Corals on outer reef tract



“The 1987 zooxanthellae expulsion event was the most massive one known in Florida.” …. ***Walt Jaap (1988)***

The Intensity and Geographical Extent Of the 1987 Coral Bleaching Event caught The attention of the US Congress

November 10, 1987

Senator Lowell P. Weicker

- Convened a **hearing in Washington**
- Committee on Appropriations
- Gather **expert testimony** on extent, possible causes and consequences of the event and to suggest a course of action

Coral Bleaching Workshop
Convened Following Hearing

St. Croix, USVI

May 1988

"Mass Bleaching of Coral Reefs in The Caribbean: A Research Strategy"

Workshop Proceedings edited by:

John C. Ogden

Robert Wicklund

1987 Workshop Objectives

- **Examine the bleaching event *post-facto*, suggest most likely hypothesis explaining it, and develop a protocol for data collection to support or reject hypotheses.**

- **Develop a protocol to examine the causes and consequences of bleaching on the organism, community and ecosystem levels.**

- **Develop a series of recommendations to follow the consequences of the bleaching event over the short-term, and suggest mechanisms to monitor the Caribbean and respond to similar events in the future.**

Ecological Effects of Bleaching

(Identified by Workshop Participants)

Short-term Effects

- immediately increases the vulnerability of coral reefs to other sources of stress
- reduced coral growth
- increased coral mortality
- emigration of corallivores
- predator concentration
- increased bioerosion
- decreased recruitment
- change in microbial loading in sediments
- increased susceptibility of corals to diseases
- change in zooplankton in the water column

Ecological Effects of Bleaching

Long-term Effects

- loss of reef framework
- decrease in spatial heterogeneity
- alteration of food webs
- decrease in coral recruitment
- decrease in fish recruitment
- loss of shoreline protection
- decreased tourism
- loss of educational benefits
- loss of species -- genetic bank
- loss of sand supply
- loss of seagrasses, mangroves
- decline in fisheries

“While notable changes in several environmental factors were observed in 1982-83 [eastern Pacific] …. the bleaching response was closely correlated with sea warming at several localities.” …. *Peter Glynn (1988)*

Recommendations for Immediate and Future Action

Immediate Action

- **Monitor selected sites** over the next year (1988) to track the bleaching event, the eventual fate of bleached corals, and gather relevant environmental data at selected research sites.

- **Monitoring protocols** should be widely distributed

- Seek **cooperation** from as many sites as possible

- Data gathered in a **standardized format** and centrally processed and made available to regional workers

- Workshop nominated **Judy Lang** to develop protocol

Future Actions

- Establish an alert and communications Center that would gather and disseminate information on phenomena such as bleaching and diseases

- A program be established to systematically study coral reefs and coastal ecosystems of the entire Caribbean and adjacent regions to collect base-line data and monitor the general health of the coastal zone - CARICOMP was in formative stages

Thermograph Locations in the FKNMS

- 32 meters to record water temperature
- 7 CMAN Stations along reef tract and Florida Bay

Coral Bleaching Trends (Cont.)

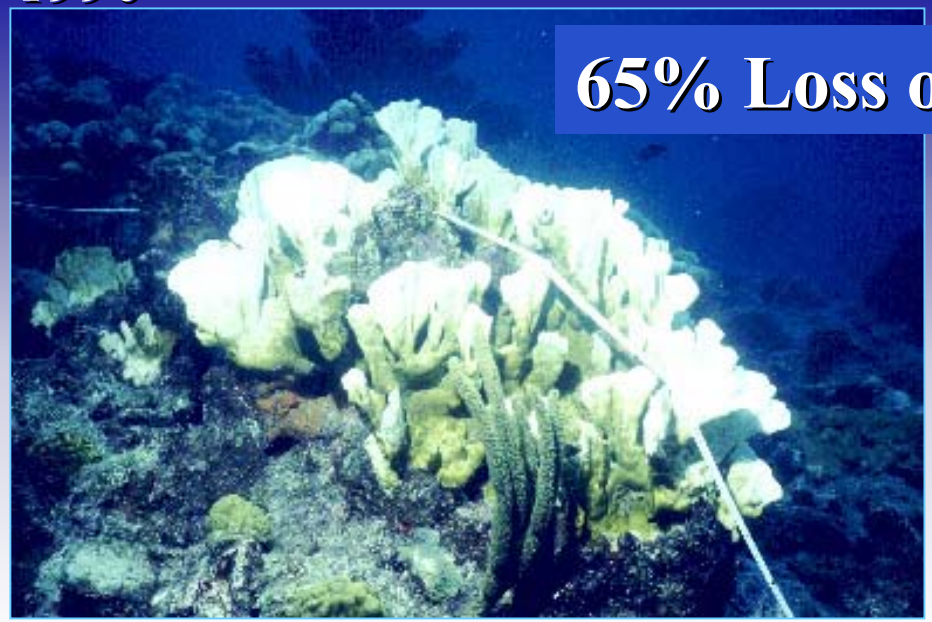
1990

- Doldrum weather patterns in July
- Massive bleaching
* Coral bleached inshore for the first time
* Large-scale coral mortality for the first time
  - 65% of fire coral on some reefs
- Global bleaching event

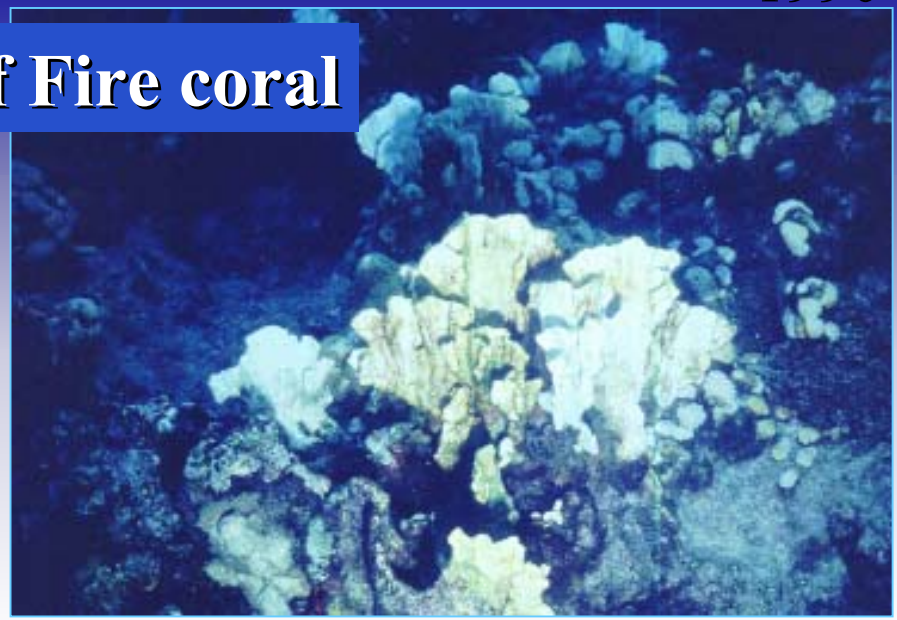
1990

1990

65% Loss of Fire coral

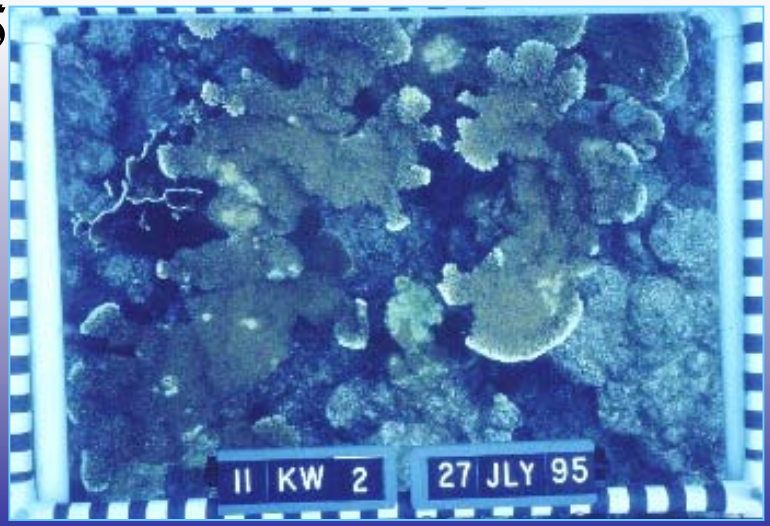


Fire coral bleaching



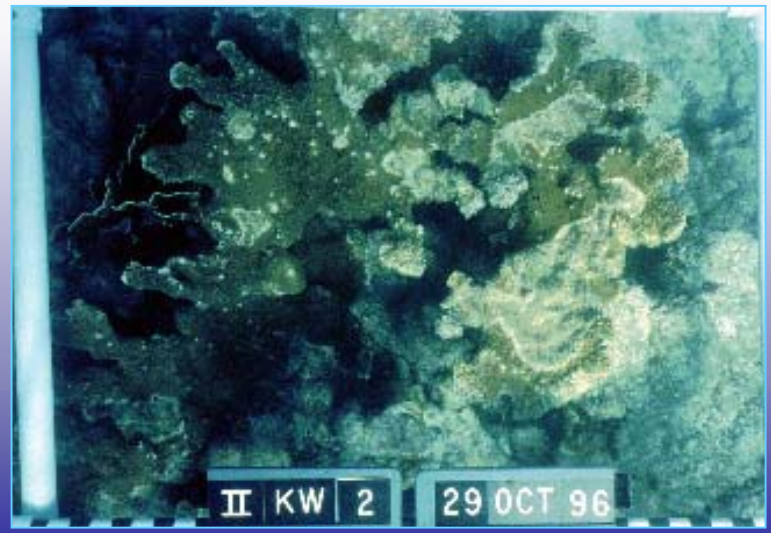
Fire coral mortality

1995



Healthy coral

1996

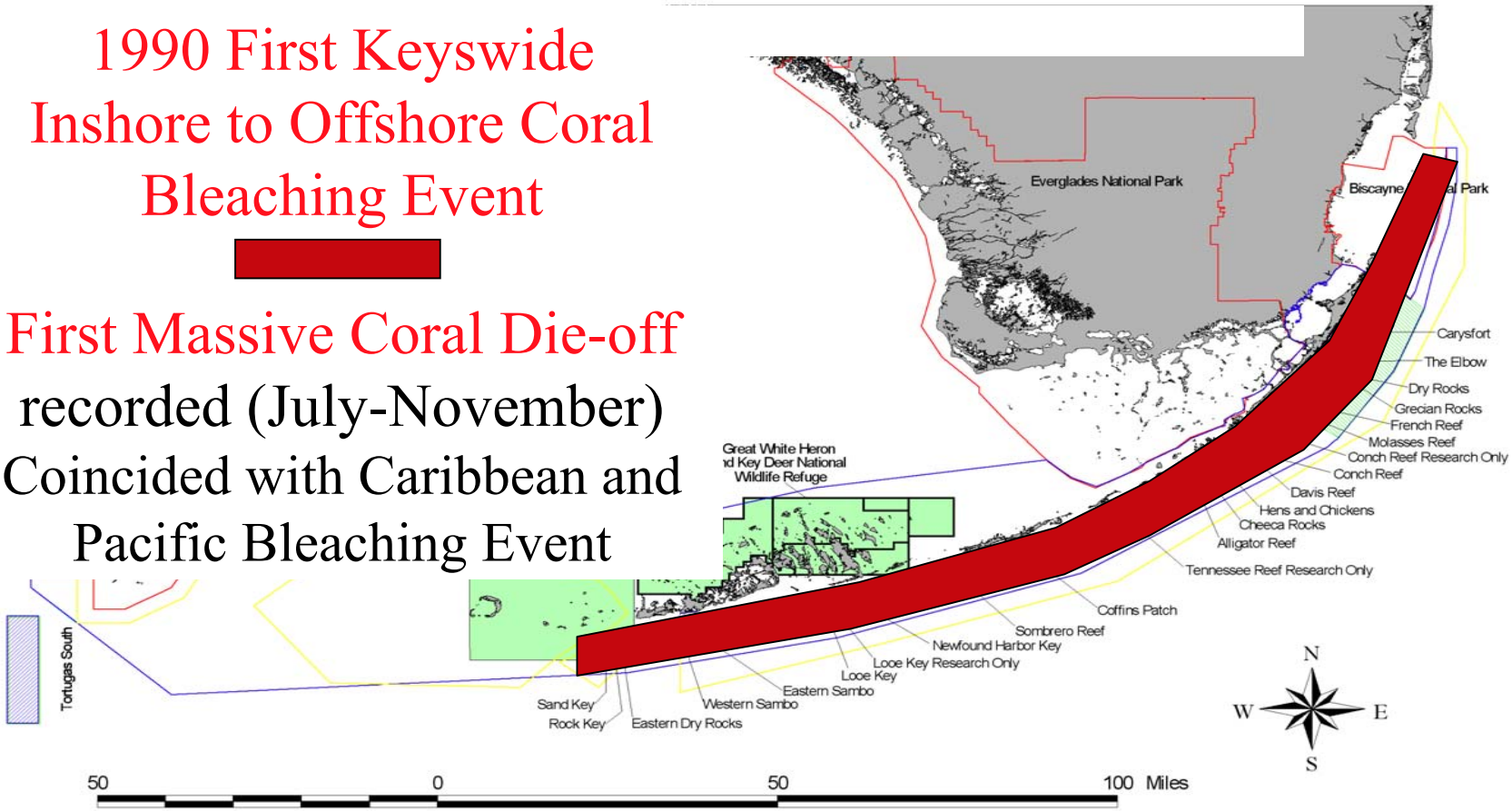


Diseased coral

Florida Keys National Marine Sanctuary

1990 First Keyswide Inshore to Offshore Coral Bleaching Event

First Massive Coral Die-off recorded (July-November) Coincided with Caribbean and Pacific Bleaching Event



Workshop on Coral Bleaching, Coral Reef Ecosystems and Global Climate Change - *Miami, Florida. June 18-21, 1991*

Organizing Committee:

Christopher F. D'Elia
Robert W. Buddemeier
Stephen V. Smith

Workshop Conclusions

- On a global average basis, coral reefs are being **lost or degraded at an alarming rate**
- At present, we lack the data needed to confirm, quantify, or explain this trend on a scientific basis
- **Bleaching merits serious study** as an indicator of coral stress and environmental quality

Workshop Conclusions (continued)

- On the basis of present understanding, definitions, and environmental records, there is no credible theoretical or empirical basis for the claim that bleaching is or can be used as a reliable indicator of global climate change

- Anthropogenic environmental alterations on global, regional, and local levels are reason for serious concern about the health and local survival of coral reef ecosystems

Workshop Recommendations For Scientific Action

- Development of a **research-oriented coral reef monitoring program** of global scale
- A **coordinated program of research** at laboratory, microcosm, and field scales
- Continued **interdisciplinary review** and **coordination of research needs** and opportunities in the area of overlap between coral reef studies and larger environmental and geoscience issues

Workshop on Coral Bleaching, Coral Reef Ecosystems and Global Climate Change - *Miami, Florida. June 18-21, 1991*

The Great Barrier Reef Marine Park Authority position:

"We presently believe that the issue most likely to prove of greatest consequence to the long term health of the GBR in the foreseeable future is that of nutrient build-up."

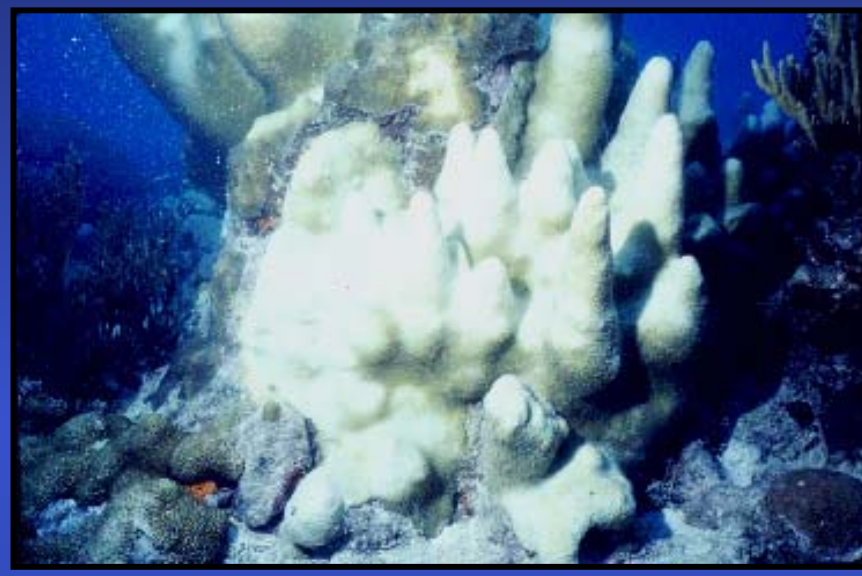
"It is totally unnecessary, and in fact very unwise to focus primarily on coral bleaching or long term climate change." ***Dr. Donald W. Kinsey - GBRMPA***

Coral Bleaching Trends (Cont.)

1997

- Doldrum weather patterns
- Massive bleaching
- Inshore and offshore corals affected
- **Alerts from 3rd generation Florida Keys residents**
- Large loss of living corals
- Global bleaching event

Coral Bleaching Trends (Cont.)



1998

- **Water remained warm from 1997**
- **Massive bleaching continued**
- **Inshore and offshore corals affected**
- **Continued loss of living corals**
- **Global bleaching event**
- * **First back-to-back annual coral bleaching**
- **Hurricane Georges**

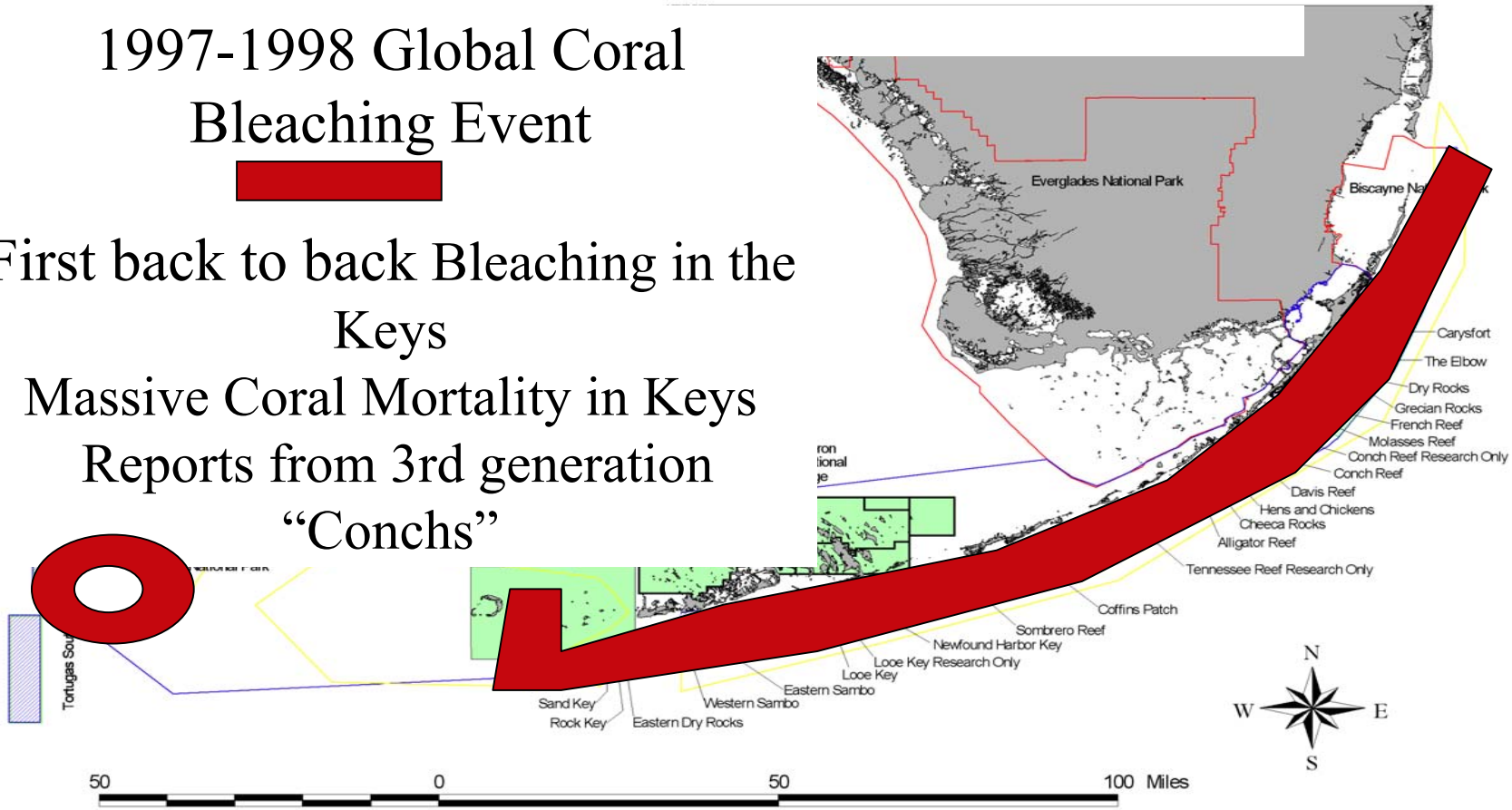
Florida Keys National Marine Sanctuary

1997-1998 Global Coral Bleaching Event

First back to back Bleaching in the Keys

Massive Coral Mortality in Keys

Reports from 3rd generation "Conchs"



*Footnote: Sept to Nov 1998 - Hurricane Georges and Tropical Storm Mitch hit Florida Keys

“The major coral bleaching and mortality event of late 1997 and 1998 was by far the worst on record and also the most widespread.

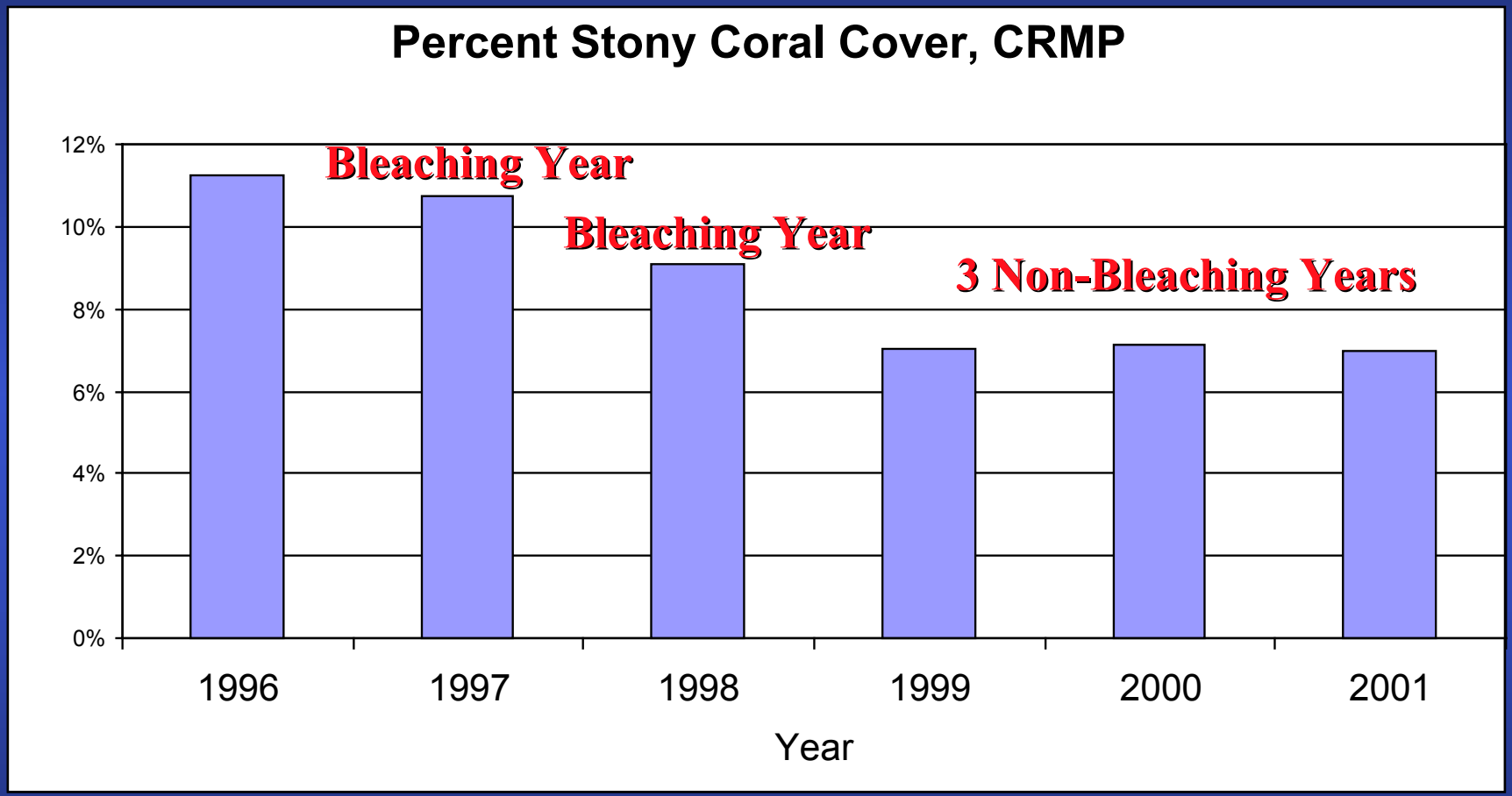
…… “Reefs in the 3 Oceans were affected with severe bleaching ……..”

Clive Wilkinson … 2002

Coral Bleaching Trends Summary

- Local patterns of increased duration
- Patterns of geographical expansion
- Coral reefs are responding to warming trends

Scientific Monitoring: Corals



Coral cover declined between 1996 and 1999 and leveled off in 2000/2001/2002.

"Coral reefs throughout the world are currently experiencing accelerated degradation."

….Wilkinson (1992, 1999)
…. Sebens (1994)

- reduced coral cover
- reduced fish abundance
- reduced species diversity
- many causal factors
- coral bleaching is major agent of change

“Mass coral bleaching is currently viewed as a major threat to the long-term health of coral reef communities.”

…. Bruno, et al (2001)

Changing Community Structure

"**Reef-building corals** are **not all equally susceptible** to the influence of increased temperature." …. *Ove Hoegh-Guldberg (2000)*

"The opposite is true of the members of the **genus *Acropora* (staghorn corals)**, which show a greater sensitivity to slight increases in water temperature …..**up to 95% of colonies may bleach and die** in the subsequent 3-6 months following the reduction in temperature stress." *(Salvat 1991; Gleason 1993; Hoegh-Guldberg 1994*

Coral Bleaching vs Other Stressors

“ Whereas global climate change alone may modify the nature of coral reef ecosystems, a change in sea temperature combined with the impact of nutrient pollution, increased sedimentation and other stresses such as destructive fishing practices may well totally eliminate reefs from some areas.”

…….Wilkinson and Buddemeier (1994)

STESSORS ON CORAL REEFS

Habitat Destruction

Coral Diseases

Nutrients from Pollution

Overfishing

Intense Coastal Development

Wastewater Nutrients

Stormwater Runoff

Massive Algal Blooms

Introduction of Marine Exotics

Management Issues Due To Coral Bleaching

- Bleaching is only one of the many stressors affecting coral reefs
- Must consider cumulative effect of bleaching along with pollution and physical destruction
- Bleaching has a major influence on the health of coral reefs
- Coral bleaching continues to geographically expand
- Upper thermal thresholds of corals and other reef inhabitants are being exceeded

Management Issues Due to Coral Bleaching

(cont.)

- Loss of biodiversity
- Loss of critical marine habitat
- Loss of important commercial and recreational fisheries
- Decline in eco-tourism will have economic impacts

"The high likelihood that there will be increases in the climate-related frequency of sea warming events causing major coral bleaching and coral death in coming decades makes effective stewardship of coral reefs and associated habitats now more important than ever."

…… *Terry Done (2001)*